clouds always do by the return radiation they themselves give out, but also decrease it, sometimes very greatly, by depositing over the ice an insulating sheet of finely powdered snow. Any substance, even a metal, when finely divided, is a poor conductor of heat, and snow is one of the poorest. Hence ice covered with a layer of fine snow, even though that layer be very thin, loses heat to colder air above much more slowly than it would if bare. Obviously, therefore, under otherwise like conditions ice increases in thickness much faster when bare than it does when snow covered.

Ice of any given thickness grows fastest when its surface is coldest; but this temperature depends in part on the condition of the air above—clear, cloudy, or foggy—and on the condition of its surface, clean or snow covered. And the fog blanket and the fine snow cover are most likely to form in relatively calm and very cold weather, drifted by the gentle movement of the air that commonly obtains on such occasions over and onto the ice sheet to the leeward of the remaining open water.

It well may be, therefore, as fishermen tell us, that at certain places, at least, along the shores of the Great Lakes more ice is formed occasionally, perhaps also on the average, when the temperature of the air is around zero Fahrenheit than there is when that temperature is even 20° to 30° lower, owing, as explained, to the greater prevalence of clear air and clean ice in the first case and foggy air and snowy ice in the second.

But here also, as everywhere and always, a few appropriate figures afford a very necessary check on one's general or qualitative reasoning. Let the conditions be:

a. Temperature of the air −18° C., 0° F., approximately. Thickness of ice, 5, 10, 25, 50 centimeters, respectively. Snow covering, none.

b. Temperature of the air −29° C., −20° F., roughly. Thickness of ice, as in cases *a*. Snow covering, 1 millimeter.

c. Same as *b* in respect to temperature of air and thickness of ice. Snow covering, 5 millimeters.

Now since the radiations of snow and ice at these low temperatures are small; the reflection of sunlight and skylight by snow roughly 90 per cent; the amount of such radiation absorbed by ice also small, especially since there is not likely to be much of it to absorb in midwinter at latitude 47° N., say; and the heat conductivity of ice very low; therefore, as a first approximation, we may assume the temperature of the top surface of the snow or bare ice to be that of the adjacent air. The temperature of the under surface of the ice is, of course, 0° C. Furthermore, as experiment has shown, the conductivity of very loose snow may be as low as one three-hundredths that of ice. Assume it, in the present case, to be one one-hundredth that value, so that as a heat insulator, a layer of our fine snow 1 millimeter deep is the equivalent of a sheet of ice 100 times as thick, 10 centimeters; a 5-millimeter covering of snow the equivalent of a 50-centimeter sheet of ice; and so on for other depths and thicknesses.

In case *a* the difference in temperature between the under and upper surfaces of the ice is 18° C., and in cases *b* and *c* the difference between the temperature of the under surface of the ice and top surface of the snow 29° C. Therefore our various temperature gradients, in terms of centigrade degrees and thicknesses, or equivalent thicknesses, in centimeters, of ice are as given in the following table:

Temperature gradients

Thickness of ice, centimeters	5	10	25	50
Bare; air −18° C	$18/5$	$18/10$	$18/25$	$18/50$
1 millimeter snow; air −29° C	$29/15$	$29/20$	$29/35$	$29/60$
5 millimeters snow; air −29° C	$29/55$	$29/60$	$29/75$	$29/100$

From these gradients it is clear that often bare ice can grow faster when the temperature of the air is 0° F. than can snow-covered ice of the same thickness when the air is much colder, even −20° F. When the thickness of the ice is 16.3 centimeters (6.4 inches) it grows just as fast in 0° F. weather, if bare, as it would with a 1-millimeter covering of loose snow (conductivity of snow one one-hundredth that of ice) in weather at −20° F. If thinner, the bare ice would grow faster than the snow covered at the given temperatures, and if thicker it would grow slower. If the depth of the snow were 5 millimeters the thickness of the ice would need to be 81.8 centimeters (32.2. inches) for the rates of growth under the given conditions to be the same.

In the first of these cases the rate of increase of thickness is about 1 centimeter in four hours, the conductivity of ice being 0.005 (transmitting 0.005 calory per second per square centimeter cross section when the temperature gradient is 1° C. per centimeter), and in the second case 1 centimeter in 20 hours.

Thus the fisherman's interesting paradox, the colder the air the thinner the ice, has become orthodox and lost its fascination.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING FEBRUARY, 1932

By HERBERT H. KIMBALL, in charge Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January, 1932 REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged above the normal intensity for February at Washington, close to the February normal at Lincoln, and slightly below at Madison.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at Chicago, New York, Fresno, Pittsburgh, Twin Falls, La Jolla, and Miami, and a deficiency at Washington, Madison, Lincoln, and Gainesville.

No skylight polarization measurements were obtained during the month. At Madison the presence of snow in the vicinity of the station made such readings of doubtful value, and at Washington the polarimeter was undergoing repairs.

TABLE 1.—*Solar radiation intensities during February, 1932*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D. C.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 1	1.24	0.86	0.97	1.14	1.28	1.44	1.30	------	------	------	1.32
Feb. 5	2.36	------	------	------	1.22	------	1.24	------	------	------	2.26
Feb. 8	7.57	------	------	------	------	------	1.25	1.09	0.92	0.75	6.50
Feb. 13	4.42	0.92	1.03	1.09	------	------	------	------	------	------	2.26
Feb. 16	2.16	------	0.85	1.00	1.18	------	------	------	------	------	2.39
Feb. 18	1.96	0.82	0.92	1.13	1.33	1.46	1.17	------	------	------	1.96
Feb. 20	2.06	0.97	1.11	1.24	1.41	1.55	------	------	------	------	1.96
Feb. 23	1.68	------	------	------	------	------	1.16	0.95	------	------	1.52
Feb. 29	4.37	0.51	0.62	0.78	------	------	------	------	------	------	4.75
Means	------	0.82	0.92	1.06	1.28	1.48	1.22	(1.02)	(0.92)	(0.75)	------
Departures	------	+0.10	+0.10	+0.07	+0.10	−0.01	+0.03	+0.04	+0.06	−0.01	------

[1] Extrapolated.

TABLE 1.—*Solar radiation intensities during February, 1932*—Continued

[Gram-calories per minute per square centimeter of normal surface]

Madison, Wis.

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass									Local mean solar time
		A. M.					P. M.				
	e.	5.0	4.0	3.0	2.0	[1] 1.0	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 3	1.37	0.73	0.93	1.18	1.34	------	1.34	1.22	------	------	1.52
Feb. 4	1.88	------	------	------	------	------	1.37	1.15	------	------	1.78
Feb. 5	1.96	------	------	1.05	1.23	------	------	1.16	------	------	2.49
Feb. 8	2.87	0.95	1.12	1.26	1.45	------	------	------	------	------	1.24
Feb. 12	2.26	0.82	1.00	1.17	1.40	------	------	------	------	------	1.88
Feb. 13	1.32	0.93	1.05	1.21	1.41	------	------	------	------	------	1.24
Feb. 18	1.52	------	------	------	1.25	------	------	------	------	------	2.62
Feb. 20	2.06	------	0.98	------	------	------	------	------	------	------	2.16
Feb. 23	1.12	------	0.82	------	1.20	------	------	------	------	------	1.02
Feb. 26	4.75	------	------	1.14	------	------	------	------	------	------	5.56
Feb. 27	4.95	------	------	------	1.19	------	------	------	------	------	5.16
Feb. 29	3.45	------	------	1.24	1.49	------	------	------	------	------	3.63
Means	------	0.86	0.98	1.18	1.33	------	(1.36)	1.18	------	------	------
Departures	------	−0.08	−0.10	−0.02	−0.03	------	±0.00	+0.01	------	------	------

Lincoln, Nebr.

Date	8 a.m.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	Noon
Feb. 3	0.96	------	0.78	0.98	------	------	------	------	------	------	0.86
Feb. 4	0.81	------	1.01	1.20	1.21	------	------	------	------	------	0.96
Feb. 5	2.36	------	------	1.15	1.33	------	------	------	------	------	3.45
Feb. 6	3.63	0.81	0.89	1.03	1.28	------	------	------	------	------	3.45
Feb. 11	4.17	------	1.05	1.22	1.36	------	1.39	1.22	1.06	0.85	3.99
Feb. 12	2.87	------	------	------	------	------	------	1.31	1.18	1.08	2.87
Feb. 17	1.52	1.03	1.18	1.31	1.45	------	1.45	1.09	0.84	0.81	1.68
Feb. 19	2.16	------	1.04	1.25	1.41	------	1.41	1.08	0.93	------	2.36
Feb. 22	1.96	0.98	1.01	1.13	1.38	------	1.23	------	------	------	2.87
Feb. 25	4.95	0.84	0.91	1.11	1.34	------	------	------	------	------	5.36
Means	------	0.95	0.98	1.15	1.34	------	1.37	1.18	1.00	0.91	------
Departures	------	+0.01	−0.03	−0.03	−0.03	------	+0.02	+0.02	−0.06	−0.01	------

[1] Extrapolated.